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ABSTRACT

This document discusses several of the most significant analytic meanings to be found in enrollment data, with the expectation that some of the already developed analytic tools, when properly tuned, can be applied to enrollment and similar data. The Induced Course Load Matrix (ICLM) is a theoretical concept developed from situations in business and industry where talk is of inputs and outputs. The input in this document is students, faculty and staff, facilities, and finances. However, students, faculty, and staff are also decision makers and cannot be manipulated in the same way as more tangible variables used in business. After consideration of enrollment data and the Induced Load Matrix it appears evident that the ICLM is best suited to macro-level analysis and decision making. The document then attempts to develop a micro-level tool that can be employed in the study of retention and attrition rates in enrollment and is useful for data requiring longitudinal study, such as enrollment statistics that take into account peer group influences. In conclusion, answers such as those sought above cannot be found in the familiar aggregate numbers game. It is more likely that one or more management science tools will play a part in the answers sought. (Author/KE)

PAPERS IN OPERATIONS ANALYSIS

Finding Analytic Meaning in College Enrollment Matrices

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THE UNIVERSITY OF TOLEDO
TOLEDO, OHIO

FINDING ANALYTIC MEANING

IN

COLLEGE ENROLLMENT MATRICES

Working Papers in Operations Analysis, No. 11

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FOREWORD

This paper was originally prepared as a staff report by the University of Toledo Office of Institutional Research of which Mr. Hill is Associate Director. It was presented to the Joint Conference of The Operations Research Society of America, The Institute of Management Sciences, and The Systems Group of the American Institute of Industrial Engineers at Atlantic City, New Jersey, November 8-10, 1972. Both of these presentations were under the title, "Finding Analytic Meaning in Enrollment Matrices." Its publication by the Business Research Center of The University of Toledo College of Business Administration, in which Mr. Judd is Professor of Operations Analysis, is in the interest of obtaining wider circulation and comment among those interested in this vital issue in college administration.

The research reported here is presently being extended under the direction of Professor Judd through this office in cooperation with the Office of Institutional Research. This extension is an attempt to address the question of "Why do students leave?"

Thomas A. Klein
Director, Business Research Center
February 8, 1973

Finding Analytic Meaning in Enrollment Matrices

Finding analytic meaning in enrollment matrices is somewhat like finding a single oak tree in a forest. There are so many oak trees, the process of deciding on one may be tortuous. And there are so many possible analytic findings in enrollment data as to make the choice of one or even a few difficult. This paper enlarges upon work of the first author begun when he served as Registrar and coincidentally, serves to extend the work of the second author.[1] Since not every analytic meaning to be found in enrollment data can possibly be discussed, several of the most significant are presented in this paper.

ICLM Model Possibilities

Projecting resource requirements through the use of Induced Course Load Matrix (ICLM) models has become quite fashionable. At least it has become fashionable to believe that ICLM is capable of predicting resource requirements. The National Center for Higher Education Management Systems at WICHE utilizes the concept in their Resource Requirements Prediction Model (RRPM).[2] California State University, Fullerton, incorporated ICLM into their pilot test of several NCHEMS techniques.[3] The Pennsylvania State University model does not use the term "ICLM" but nevertheless employs the same concepts for use in predicting instructional activity.[4]

ICLM is a theoretical concept, conceptualized from situations in business and industry where we talk of inputs and outputs. In business and industry one can establish, with almost unfailing certainty, the various outputs that will result from the introduction of various inputs. The inputs of sand, gravel, cement, and water into the mixer produces an output of concrete, the properties of which can be determined through input variation. The decision to use Type II Cement rather than Portland Cement produces certain predictable results.

NOTE: The authors want to acknowledge the significant help of Ronald L. Webster and Dean A. Berkey, Programmer-Analysts, and Thomas J. Greene, Mgr. Application Systems, University of Toledo Computer Services on this research project.

Input into the educational "mixer," the university, consists of, at least, students, faculty and staff, facilities, and finances. However, where inputs of sand, gravel, cement, and water are manipulated by the decision-maker responsible for the output, some inputs to the educational system (i.e., students, faculty and staff) are also decision-makers and as a result cannot be manipulated in the same manner possible in producing concrete.

In an attempt to minimize the impact of decision-making on the part of students, the concept of the student flow model has been utilized.[5] Using historical data, retention and attrition are analyzed by major and student level in order to determine the major and level movement from period to period for student body. Thus, the probabilities that become associated with groups of students (e.g., freshmen history majors) are based on the actual experience of each freshman history major in the period under analysis. Each student has decision possibilities and his decisions are then combined with those of all others in his group to form the basis for assignment of probabilities for decisions that will be made by a subsequent group of students assigned to the same classifications as were the students whose performance determined the probabilities.

Each student has identical decision possibilities but different probability possibilities. Exhibit 1 (top row and left column) shows the decision-making situation confronting each student. Each will, in fact, make a decision, but given a large enough group of decision makers, the results of their actions individually will tend to be distributed in such a manner that the probabilities are considered as accurate indicators of student flow. For any individual student his probabilities are based on items quite apart from the decisions of similar students in the analysis; his probabilities are based

EXHIBIT 1

DECISION POSSIBILITIES	A KEEP MAJOR	B CHANGE MAJOR	C QUIT SCHOOL	
1 KEEP LEVEL	P_{1A}	P_{1B}	P_{1C}	P_1
2 CHANGE LEVEL	P_{2A}	P_{2B}	P_{2C}	P_2
	P_A	P_B	P_C	1.00

PROBABILITIES:

P_{1A} - of keeping level and keeping major

P_{1B} - of keeping level and changing major

P_{1C} - of quitting school before completing level

P_{2A} - of changing level and keeping major

P_{2B} - of changing level and changing major

P_{2C} - of quitting school at completion of level

P_1 - of keeping level

P_2 - of changing level

P_A - of keeping major

P_B - of changing major

P_C - of quitting school

on items important to him, such as grades, financial resources, and emotional maturity, to name a few.

Two requirements of successful student flow modeling are a large enough population and condition of "all other things being equal" from the period of basing the probabilities to the period of prediction. Assuming that the student flow model properly distributes our student body, we must then again rely on historical data to develop the ICLM.

Just as the student flow probabilities were determined as the result of actual decisions of students made on the basis of personally influencing factors, the ICLM is the result of decisons made in a prior time--decisions based on available facilities, finances, faculty and staff, and previous results obtained by the students (e.g., grade earned from a certain instructor). As we shall see, administrative decision-making can have a pronounced effect on course enrollments. Furthermore, we shall see that largeness of numbers is necessary to make the ICLM appear to work but that when a microanalysis is performed on actual data at The University of Toledo the ICLM does not perform satisfactorily.

Freshmen English Composition (English 101) was chosen for analysis because it is one of the two courses required of all baccalaureate students for graduation. A computer program specifically written for analysis of course enrollments by students' levels and colleges provided the summary enrollment picture. This program provided computer output, an example of which is shown in Exhibit 2.

EXHIBIT 2

ENROLLMENT IN COURSES BY COLLEGE BY CLASS RANK--
FALL 1971

				SEP	JAN	MAR	HOLD FRSH	SOPH	JUNR	SENR	UWD	MSTR	MTR&	DOCT	OTHR
ENGL 113-101	AS	548	52.1	446			73	22	6			1			
	BA	79	07.5	17			53	8	1						
	ED	368	35.0	299			56	10	2	1					
	EN	38	03.6	1			25	10	1	1					
	PH	17	01.6	13			4								
	UC	2	00.2	1			—	1	—	—		—			
	TOT	1052	100.0	777			211	51	10	2		1			

Enrollment summaries in English 101 were gathered for fall quarters of 1969, 1970, and 1971 and are shown in Exhibit 3. Also shown in Exhibit 3 is the headcount of all entering freshmen from the fall quarter for the three years under study. The percentage distribution in the course by class rank shows that a constant percentage of entering freshmen are enrolling in English 101 in the fall quarter of each year--namely, about 27% of them.

EXHIBIT 3

	1969	1970	1971
Fall entering freshmen enrolled in English 101	8	868	777
Fall entering freshmen--total headcount	2,992	3,153	2,882
% of entering freshmen enrolled in English 101	27.8	27.5	27.0

Exhibit 4 utilizes the same data and breaks down the freshmen into two groups--those enrolled through the professional schools and those enrolled through the Arts and Sciences College. It is evident that this breakdown, even though we are still dealing with large numbers, does not afford us the consistency found in Exhibit 3. In the three years under analysis, the percentage of entering freshmen in professional schools that enrolled for English 101 in that fall quarter varied from 18.5% to 24.5%. Similarly, the Arts & Sciences College entering freshmen percentage varied from 36.3% to 40.9%. Therefore use of

EXHIBIT 4

	1969	1970	1971
Fall entering freshmen enrolled in English 101--Professional Schools	529	480	331
Fall entering freshmen enrolled in English 101--Arts and Sciences	303	388	446
Fall entering freshmen enrolled in English 101--All	832	868	777
Fall entering freshmen--Professional Schools	2,158	2,204	1,788
Fall entering freshmen--Arts and Sciences	834	949	1,094
Fall entering freshmen--All	2,992	3,153	2,882
% of entering freshmen enrolled in English 101--Professional Schools	24.5	21.8	18.5
% of entering freshmen enrolled in English 101--Arts and Sciences	36.3	40.9	40.8
% of entering freshmen enrolled in English 101--All	27.8	27.5	27.0

an ICLM on English 101 for entering freshmen is more difficult and calls for more judgment when the college of enrollment is known even to the limited extent of Arts and Sciences vs. all others (professional schools).

Exhibit 5 carries this analysis one step further to indicate the results when the college of enrollment in the professional schools is known. The results of this analysis are startling. Three years ago, entering freshmen in Business Administration took English 101 at the rate of 54.1%; in 1971, only 6.2% of the College's entering freshmen took English 101 in fall quarter. Engineering's percentage of participation dropped slightly, whereas Education and Pharmacy entering freshmen increased their rate of participation in English 10

EXHIBIT 5

	1969	1970	1971
Entering freshmen enrolled in English 101			
Arts and Sciences	303	388	446
Business Administration	173	38	17
Education	342	427	219
Engineering	7	4	1
Pharmacy	0	8	13
Other	7	3	1
TOTAL	832	868	777
Entering freshmen--total			
Arts and Sciences	834	949	1,094
Business Administration	320	280	275
Education	682	109	491
Engineering	243	283	188
Pharmacy	41	56	73
Other	872	876	161
TOTAL	2,992	3,153	2,882
% of entering freshmen enrolled in English 101			
Arts and Sciences	36.3	40.9	40.8
Business Administration	54.1	13.6	6.2
Education	50.1	60.2	60.9
Engineering	2.9	1.4	0.5
Pharmacy	0.0	14.3	17.8
Other	0.8	0.3	0.1
TOTAL	27.8	27.5	27.0

The consistency of performance decreases as the levels of disaggregation increase and the incorporation of data into the ICLM requires more value judgment and estimation.

Exhibit 6 shows a further complication in our efforts to utilize ICLM in resource allocation. This shows that the percentage of students enrolled in English 101 that are entering freshmen is not constant over time. In 1969, 85.1% of the students in English 101 were entering freshmen, whereas, in 1971, 73.9% of them were entering freshmen. The record of participation by college is even more inconsistent. For example, where entering freshmen in Business Administration once made up 17.7% of the population in English 101, they now make up only 1.6%.

There are some explanations of why Exhibit 6 shows what it does. (1) Administratively, the decision was made to keep the <u>total</u> enrollment in English 101 the same (roughly) as it was the previous year, even in the face of a falling enrollment of entering freshmen. (2) The opportunity for continuing students (holdover freshmen and other) to register for English 101 for Fall Quarter 1971 was increased due to a change in the registration system. In Fall Quarter 1970, entering freshmen had first choice for the course; in Fall Quarter 1971, the continuing students had first choice. (3) Business Administration decided to defer, where possible, their students' enrollments into English 101 beginning with Fall Wuarter 1970.

Decision (1) above, in part, brought about the opportunity for more students relative to the student population to enter English 101. This, when coupled with decision (2) above, allowed the participation of entering freshmen, in total, to reach the levels of other years, after providing capacity for students who had deferred English 101 and now wished to enroll. Decision (3) above

EXHIBIT 6

UNIVERSITY REQUIREMENT ENROLLMENT IN ENGLISH 101

	FALL 1969 HEADCOUNT				FALL 1970 HEADCOUNT				FALL 1971 HEADCOUNT			
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL
Arts & Sciences	303	29	7	339	388	64	10	462	446	73	29	548
Business Admin.	173	26	16	215	38	23	8	69	17	53	9	79
Education	342	41	14	397	427	59	13	499	299	56	13	368
Engineering	7	6	2	15	4	15	8	27	1	25	12	38
Pharmacy	0	1	0	1	8	1	0	9	13	4	0	17
Other	7	1	3	11	3	1	0	4	1	0	1	2
TOTAL	832	104	42	978	868	163	39	1,070	777	211	64	1,052

	FALL 1969 % DISTRIBUTION				FALL 1970 % DISTRIBUTION				FALL 1971 % DISTRIBUTION			
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL
Arts & Sciences	31.0	3.0	0.7	34.7	36.3	6.0	1.0	43.3	42.4	6.9	2.8	52.1
Business Admin.	17.7	2.6	1.7	22.0	3.6	2.1	0.7	6.4	1.6	5.0	0.9	7.5
Education	35.0	4.2	1.4	40.6	39.9	5.5	1.2	46.6	28.4	5.3	1.2	34.9
Engineering	0.7	0.6	0.2	1.5	0.4	1.4	0.7	2.5	0.1	2.4	1.1	3.6
Pharmacy	0.0	0.1	0.0	0.1	0.7	0.1	0.0	0.8	1.3	0.4	0.0	1.7
Other	0.7	0.1	0.3	1.1	0.3	0.1	0.0	0.4	0.1	0.0	0.1	0.2
TOTAL	85.1	10.6	4.3	100.0	81.2	15.2	3.6	100.0	73.9	20.0	6.1	100.0

brought about, in part, the shifts in class make-up by college, because the seats that Business Administration no longer controlled filled with students from other colleges.

Exhibit 7 shows our attempt to find analytic meaning in the enrollments for Fall Quarter 1969, 1970, and 1971, in the only other university-wide requirement--Physical Education 108. The percentage of entering freshmen in total varies from 20.3 in 1969 to 26.1 in 1970. Analysis by college of enrollment shows fluctuations far greater than that revealed by the analysis of English 101 data. As with English 101, the more you know about the student (in this case, only the college of matriculation), the less the ability to find analytic meaning.

EXHIBIT 7

	1969	1970	1971
Entering freshmen enrolled in Physical Education 108			
Arts and Sciences	262	379	400
Business Administration	140	174	156
Education	295	507	326
Engineering	51	21	42
Pharmacy	30	32	25
Other	38	2	23
TOTAL	816	1,115	972
Entering freshmen--total			
Arts and Sciences	834	949	1,094
Business Administration	320	280	275
Education	682	709	491
Engineering	243	283	188
Pharmacy	41	56	73
Other	872	876	761
TOTAL	2,992	3,153	2,882
% of entering freshmen enrolled in Physical Educ. 108			
Arts and Sciences	25.3	31.4	27.3
Business Administration	38.1	46.8	43.3
Education	32.1	50.8	44.2
Engineering	14.4	1.4	3.7
Pharmacy	7.3	50.0	30.1
Other	2.1	0.1	0.8
TOTAL	20.3	26.1	23.2

EXHIBIT 8

UNIVERSITY REQUIREMENT--
ENROLLMENT IN PHYSICAL EDUCATION 108

	FALL 1969 HEADCOUNT				FALL 1970 HEADCOUNT				FALL 1971 HEADCOUNT			
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL
Arts & Sciences	211	31	20	262	298	48	33	379	299	64	37	400
Business Admin.	122	13	5	140	131	28	15	174	119	24	3	156
Education	219	49	27	295	360	87	60	507	217	56	53	326
Engineering	35	12	4	51	4	14	3	21	7	25	10	42
Pharmacy	3	1	26	30	28	3	1	32	22	3	0	25
Other	18	20	0	38	1	0	1	2	6	10	7	23
TOTAL	608	126	82	816	822	180	113	1,115	670	182	120	972

	FALL 1969 % DISTRIBUTION				FALL 1970 % DISTRIBUTION				FALL 1971 % DISTRIBUTION			
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL
Arts & Sciences	25.9	3.8	2.4	32.1	26.7	4.3	2.9	33.9	30.8	6.6	3.8	41.2
Business Admin.	15.0	1.6	0.6	17.2	11.7	2.5	1.3	15.5	12.2	2.5	1.3	16.0
Education	26.7	6.0	3.3	36.0	32.3	7.8	5.4	45.5	22.3	5.8	5.5	33.6
Engineering	4.3	1.5	0.5	6.3	0.4	1.3	0.3	2.0	0.7	2.6	1.0	4.3
Pharmacy	0.4	0.1	3.2	3.7	2.5	0.3	0.1	2.9	2.3	0.3	0.0	2.6
Other	2.2	2.5	0.0	4.7	0.1	0.0	0.1	0.2	0.6	1.0	0.7	2.3
TOTAL	74.5	15.5	10.0	100.0	73.7	16.2	10.1	100.0	68.9	18.8	12.3	100.0

Exhibit 8 shows that entering freshmen do not make up a constant percentage of the total enrollment, providing 74.5% in 1969, 73.7% in 1970, and only 68.9% in 1971. As soon as we look at the college of enrollment, the data provide less consistent information from year to year--the same situation we experienced with English 101.

Administrative decisions on total enrollment and changes in registration procedures, as alluded to earlier, affect the actual enrollment of students in Physical Education 108. Furthermore, also operating on the system is the nature of these courses. That is to say, English 101 is a prerequisite for other courses and knowledge of the fundamentals of composition is presumed in many other courses (history term papers, for example). Physical Education 108, on the other hand, is considered by many students as a "filler" course, to be taken any time during the college experience; hence, no particular rush to enroll during the first quarter.

College-wide requirements of three professional schools were identified and their enrollments analyzed. It was presumed that if the enrollment data had more meaning at this level of disaggregation, then further breakdowns, such as to major, would provide even greater analytic meaning. If the college-wide requirements provided data that had less meaning than that found in the two university-wide requirements, then to analyze at the level of major would provide less meaningful data yet.

Exhibit 9 shows enrollment data for Operations Analysis 119, a college-wide requirement for the College of Business Administration. This exhibit shows that entering freshmen participated at a rate of 29.7% in 1969, 31.1% in 1970, and 73.1% in 1971. However, of the total students in the course, in

1969, 47.5% were Business Administration entering freshmen, in 1970, 33.0% were Business Administration entering freshmen, and in 1971, 48.1% were Business Administration entering freshmen. Students from other colleges provided 8.5% of the total enrollment in 1969, 5.2% in 1970, and 8.4% in 1971. This analysis provides us with information that is far less consistent than that found in English 101, and somewhat less than that found in Physical Education 108.

Exhibit 10 shows enrollment data for Foundations 130, a college-wide requirement for the College of Education. Entering freshmen in the college participated at a rate of 34.2% in 1969, 40.5% in 1970, and 44.0% in 1971. Of the total students in the course, in 1969, 38.0% were entering freshmen from Education, in 1970, 49.7% were entering freshmen from Education, and in 1971, 57.3% were entering freshmen from Education. Students from other colleges provided 10.8% of the course enrollment in 1969, 8.0% in 1970, and 9.5% in 1971. This analysis seems to show a consistency approximately that of Physical Education 108.

Exhibit 11 shows enrollment data for Graphics 121, a college-wide requirement for the College of Engineering. Entering freshmen in the college participated at a rate of 90.9% in 1969, 92.2% in 1970, and 95.7% in 1971. Of the total students in the course, 78.1% were entering freshmen from Engineering in 1969, 81.3% were entering freshmen from Engineering in 1970, and 81,8% were entering freshmen from Engineering in 1971. Students from other schools provided 6.7% of the enrollment in 1969, 4.7% of the enrollment in 1970, and 7.3% of the enrollment in 1971. This analysis indicates that the enrollment situation in Graphics 121 is no more stable and predictable than that of either the college-

EXHIBIT 9

COLLEGE REQUIREMENT-- BUSINESS ADMINISTRATION
ENROLLMENT IN OPERATIONS ANALYSIS 119

	FALL 1969 HEADCOUNT				FALL 1970 HEADCOUNT				FALL 1971 HEADCOUNT				FALL ENTER. FRESHMEN TOTAL HEADCOUNT		
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	1969	1970	1971
Business Admin.	95	27	61	183	87	51	112	250	201	75	107	383	320	280	275
Other	7	2	8	17	2	3	9	14	2	11	22	35	2,672	2,873	2,607
TOTAL	102	29	69	200	89	54	121	264	203	86	129	418	2,992	3,153	2,882

	FALL 1969 % DISTRIBUTION				FALL 1970 % DISTRIBUTION				FALL 1971 % DISTRIBUTION				FALL % OF ENTERING FRESHMEN TAKING OP. ANAL. 119		
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	1969	1970	1971
Business Admin.	47.5	13.5	30.5	91.5	33.0	19.4	42.4	94.8	48.1	18.0	25.5	91.6	29.7	31.1	73.1
Other	3.5	1.0	4.0	8.5	0.7	1.1	3.4	5.2	0.5	2.6	5.3	8.4	0.3	0.1	0.1
TOTAL	51.0	14.5	34.5	100.0	33.7	20.5	45.8	100.0	48.6	20.6	30.8	100.0	3.4	2.8	7.0

EXHIBIT 10

COLLEGE REQUIREMENT-- EDUCATION
ENROLLMENT IN FOUNDATIONS 130 (& 101 IN 1971)

	FALL 1969 HEADCOUNT				FALL 1970 HEADCOUNT				FALL 1971 HEADCOUNT				FALL ENTER. FRESHMEN TOTAL HEADCOUNT		
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	1969	1970	1971
Education	233	162	152	547	287	127	117	531	216	82	43	341	682	709	491
Other	7	18	41	66	7	15	24	46	1	16	19	36	2,310	2,444	2,391
TOTAL	240	180	193	613	294	142	141	577	217	98	62	377	2,992	3,153	2,882

	FALL 1969 % DISTRIBUTION				FALL 1970 % DISTRIBUTION				FALL 1971 % DISTRIBUTION				FALL % OF ENTERING FRESHMEN TAKING FOUND. 130		
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	1969	1970	1971
Education	38.0	26.4	24.8	89.2	49.7	22.0	20.3	92.0	57.3	21.8	11.4	90.5	34.2	40.5	44.0
Other	1.1	3.0	6.7	10.8	1.2	2.6	4.2	8.0	0.3	4.2	5.0	9.5	0.3	0.3	0.0
TOTAL	39.1	29.4	31.5	100.0	50.9	24.6	24.5	100.0	57.6	26.0	16.4	100.0	8.0	9.3	7.5

EXHIBIT 11

COLLEGE REQUIREMENT--ENGINEERING
ENROLLMENT IN GRAPHICS 121

	FALL 1969 HEADCOUNT				FALL 1970 HEADCOUNT				FALL 1971 HEADCOUNT				FALL ENTER. FRESHMEN TOTAL HEADCOUNT		
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	1969	1970	1971
Engineering	221	33	10	264	261	37	8	306	180	17	7	204	243	283	188
Other	8	7	4	19	8	5	2	15	9	5	2	16	2,749	2,870	2,694
TOTAL	229	40	14	283	269	42	10	321	189	22	9	220	2,992	3,153	2,882

	FALL 1969 % DISTRIBUTION				FALL 1970 % DISTRIBUTION				FALL 1971 % DISTRIBUTION				FALL % OF ENTERING FRESHMEN TAKING GRAPHICS 121		
	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	Entering Freshmen	Holdover Freshmen	Other	TOTAL	1969	1970	1971
Engineering	78.1	11.7	3.5	93.3	81.3	11.5	2.5	95.3	81.8	7.7	3.2	92.7	90.9	92.2	95.7
Other	2.8	2.5	1.4	6.7	2.5	1.6	0.6	4.7	4.1	2.3	0.9	7.3	0.3	0.3	0.3
TOTAL	80.9	14.2	4.9	100.0	83.8	13.1	3.1	100.0	85.9	10.0	4.1	100.0	7.7	8.5	6.6

wide requirements analyzed (Operations Analysis 119 and Foundations 130) or the university-wide requirements (English 101 and Physical Education 108).

Even though our assumption of "less information yields more analytic meaning" seems to be proved true when analysis moves from class rank only to college and class rank, it was felt that an inspection of data by major, by rank, by college was necessary to further substantiate these findings. Exhibit 12 shows the layout, with examples, of a computer program designed to extend the search performed by college and rank (see Exhibit 2) to search also for the major of each student enrolled. A comparison of this information with that contained in the "Report on Student Enrollment," published quarterly by the Office of Admissions and Records will show any consistency that may exist that will aid us in finding analytic meaning in enrollment data. Even though this information is available on all levels of students, only entering freshmen are displayed in Exhibit 13 as to English 101.

EXHIBIT 12

COURSE ENROLLMENTS BY MAJOR AND BY CLASS RANK, FALL 1971

COURSE NBR	MAJOR	SEPT FRESH	JAN FRESH	APRIL FRESH	HOLD FRESH	SOPH	JUN	SEN	UWD	MAST	DOCT	OTHER	TOTAL
113-101-00	100	2			2								4
	103	16			2								18
	112	214			35	6	1						256
	113	9											9
	115	5			1								6
	...												...
	...												...
	...												...
	484				7	4		1					12
	600	13											13
	601				4								4
	702	1											1
COURSE TOTAL		777			211	51	10	2		1			1052

EXHIBIT 13

MAJORS ENROLLED IN ENGLISH 101
AND TOTAL MAJORS-ENTERING FRESHMEN

	1970			1971		
	Enrolled	Total	%	Enrolled	Total	%
Arts & Sciences						
Undecided	121	236	51.3	2	5	40.0
Art	19	32	59.4	16	36	44.4
General	65	138	47.1	215	382	56.3
English	13	20	65.0	10	10	100.0
Predentistry	4	9	44.4	5	12	41.7
French	2	4	50.0	1	3	33.3
Premedical	17	51	33.3	29	96	30.2
German	0	0	00.0	1	3	33.3
Interdepartmental	0	1	00.0	3	5	60.0
History	10	22	45.5	11	19	57.9
Journalism	15	25	60.0	13	23	56.5
Music	1	9	11.1	3	17	17.6
Philosophy	0	2	00.0	3	5	60.0
Spanish	2	3	66.7	0	3	00.0
Speech	3	4	75.0	2	4	50.0
Theater	1	8	12.5	7	20	35.0
Biology	11	29	37.9	17	44	38.6
Chemistry	5	12	41.7	11	25	44.0
Geology	1	1	100.0	2	2	100.0
Mathematics	15	35	42.9	5	15	33.3
Medical Technology	19	25	76.0	9	28	32.1
Physics	5	10	50.0	5	9	55.6
X-Ray	0	41	00.0	0	36	00.0
Anthropology	0	0	00.0	0	2	00.0
Economics	0	1	00.0	1	2	50.0
Geography	0	1	00.0	0	1	00.0
International Relations	0	0	00.0	0	1	00.0
Political Science	6	16	37.5	19	28	67.9
Psychology	25	35	71.4	31	60	51.7
Sociology	27	46	58.7	23	43	53.5
Nursing	1	133	00.8	2	155	01.3

EXHIBIT 13 (cont.)

	1970			1971		
	Enrolled	Total	%	Enrolled	Total	%
Total Arts & Sciences	388	949	40.9	446	1,094	40.8
Business Administration						
General	27	208	13.0	13	241	05.4
Accounting	6	34	17.6	3	20	15.0
Administration	2	13	15.4	0	2	00.0
Personnel	1	1	100.0	0	1	00.0
Business Economics	0	1	00.0	0	1	00.0
Finance	0	7	00.0	0	3	00.0
Marketing	2	14	14.3	1	3	33.3
Office Administration	0	1	00.0	0	3	00.0
Operations Analysis	0	1	00.0	0	1	00.0
Total Business Admin.	38	280	13.6	17	275	06.2
Education						
Undecided	116	170	68.2	41	82	50.0
Educational Media	2	2	100.0	0	0	00.0
Early Childhood	17	24	70.8	0	0	00.0
Elementary Education	132	220	60.0	127	182	69.8
English	36	57	63.2	21	27	77.8
Foreign Language	13	27	48.1	6	13	46.2
Curriculum & Teaching	15	19	78.9	0	0	00.0
Mathematics	29	45	64.4	14	26	53.8
Science	2	3	66.7	4	6	66.7
Speech	0	3	00.0	1	1	100.0
Social Science	11	29	37.9	8	18	44.4
Special Education	8	13	61.5	14	27	51.9
Secondary Education	0	1	00.0	7	8	87.5
Health	0	3	00.0	1	1	100.0
Library Science	2	2	100.0	1	1	100.0
Physical Education	5	21	23.8	34	46	73.9
Vocational Education	1	7	14.3	0	5	00.0
Art Education	24	31	77.4	12	24	50.0

EXHIBIT 13 (cont.)

	1970			1971		
	Enrolled	Total	%	Enrolled	Total	%
Education (cont.)						
Business Education	11	22	50.0	6	11	54.5
Music Education	3	10	30.0	2	13	15.4
Total Education	427	709	60.2	299	491	60.9
Engineering						
Unclassified	3	83	03.6	0	3	00.0
Chemical Engineering	0	37	00.0	0	30	00.0
Civil Engineering	0	33	00.0	0	36	00.0
Electrical Engineering	0	62	00.0	1	58	01.7
Engineering Science	0	0	00.0	0	7	00.0
Engineering Physics	1	10	10.0	0	0	00.0
Industrial Engineering	0	10	00.0	0	7	00.0
Mechanical Engineering	0	48	00.0	0	47	00.0
Total Engineering	4	283	01.4	1	188	00.5
Pharmacy	8	56	14.3	13	73	17.8
Other	3	876	00.3	1	761	00.1
University Total	868	3,153	27.5	777	2,882	27.0

Exhibit 13 shows that the percentage of participation in English 101 in the fall quarters by student major for entering freshmen varies widely from 1970 to 1971. As such, it is obvious that knowledge of a student's major makes prediction of enrollment in English 101 even more difficult than knowing only students' college. And knowing the college, you will recall, made enrollment prediction more difficult than mere knowledge of student rank.

Retention and Attrition Analysis Possibilities

From the preceding consideration of the enrollment data and the Induced Course Load Matrix it appears evident that the ICLM is best suited to macro-level analysis and decision-making. It remains to be seen whether there are micro-level tools that can be employed to yield analytic results when applied to enrollment data.

A critical area of decision-making is that of retention and attrition. To get an analytical handle on this problem every freshman entering the University of Toledo in the fall of 1969 was followed up through his or her course registrations in that fall quarter and subsequent quarters. Some idea of the magnitude of this task can be seen when it is realized that the 2,992 entering freshmen develop almost 68,000 individual course registration records to be scrutinized in the course of ten quarters records available on computer tape.

In terms of a manageable size for analysis in this paper, there were five samples, each of 100 students, drawn from a complete listing of the 2,992, representing five units of contiguous pages in the computer printout. This printout was ordered by social security number and the selection of groups of pages that comprised the five samples included the first forty pages of listings, three other groups of pages from the page 300, page 600 and page 800 segments of the printout, plus a final unit of pages from the end of the printout. In the social security number system the only possible bias could arise from the local student's numbers tending to cluster with possible adverse effects on the ultimate representativeness of the sample. In terms of representativeness, the following table may be instructive:

EXHIBIT 14

Distribution of Freshmen, Fall 1969

	Actual College Percent Enrollment	Sample College Percent Enrollment
Arts and Science	27.9%	29.8%
Business Administration	10.7	11.0
Education	22.8	20.6
Engineering	8.1	8.4
Pharmacy	1.4	1.0
Comm. Tech.	29.1	29.2
	100.0%	100.0%

One of the first findings of analytic significance in the sample of 500 involved in this undertaking was the size of the "non-consecutive" enrollment group. It has become popular to point out the drop-out, step-out phenomenon. As of the present sample it involved almost 15% of the entering freshman group. Much more work is programmed to be done on this sub-population, but present findings suggest that the in-and-out, here today-gone next quarter-back sometime later, behavior may contribute to the difficulty in using forecasting tools that have in earlier years yielded adequate results. We found that some students were registered, and then not registered and then returned as many as three separate times in the ten quarters studied. Their leaving did not appear to be associated with grade difficulties and a separate inquiry is planned to attempt to learn something of the reasons for their behavior.

The complete detail of student registration in terms of the total sample is given in Exhibits 15 & 16.

EXHIBIT 15

Number of Students Registering in Consecutive Quarters

No. of Consecutive Qtrs. of Registration	Samples 1	2	3	4	5	Total All Samples
1	6	15	17	13	4	55
2	3	7	6	2	3	21
3	21	13	8	8	13	63
4	1	2	3	6	4	16
5	4	5	8	5	4	26
6	14	7	4	11	8	44
7	2	3	5	5	6	21
8	3	2	5	3	7	20
9	37	16	20	22	31	126
10	3	7	8	6	10	34
Non-consecutive	6	23	16	19	10	74
Total	100	100	100	100	100	500

EXHIBIT 16

Percent of Students Registering in Consecutive Quarters

No. of Consecutive Qtrs. of Registration	1 & 2	1,2&3	1, 2, 3 & 4	1,2,3 4 & 5	Cumulative All	Reverse Cumulative All
1	10.5	12.7	12.7	11.0	-	100.0
2	5.0	5.3	4.5	4.2	15.2	89.0
3	17.0	14.0	12.5	12.6	27.8	84.8
4	1.5	2.0	3.0	3.2	31.0	72.2
5	4.5	5.7	5.5	5.2	36.2	69.0
6	10.5	8.3	9.0	8.8	45.0	63.8
7	2.5	3.3	3.7	4.2	49.2	55.0
8	2.5	3.3	3.3	4.0	53.2	50.8
9	26.5	24.4	23.8	25.2	78.4	46.8
10	5.0	6.0	6.0	6.8	85.2	21.6
Non-consecutive	14.5	15.0	16.0	14.8	100.0	-
Total	100.0	100.0	100.0	100.0		

When the registration of this student sample is considered in terms of the college of initial registration the data looks like Exhibit 17. From this it is possible to construct the tables found in Exhibits 18, 19 and 20.

EXHIBIT 17

Number of Students Registering in Consecutive Quarters by College of Initial Registration

No. of Consecutive Qtrs. of Registration	Arts & Science	Bus. Adm.	Education	Engineering	Pharmacy	Comm. Tech	Total
1	15	6	6	5	1	22	55
2	6	0	3	1	0	11	21
3	20	6	14	5	1	17	63
4	4	1	5	0	0	6	16
5	1	7	7	1	0	10	26
6	23	4	8	0	0	9	44
7	4	1	1	3	0	12	21
8	4	4	2	0	0	10	20
9	38	16	34	20	3	15	126
10	10	4	12	4	0	4	34
Non-consecutive	24	6	11	3	0	30	74
Total	149	55	103	42	5	146	500

The table in Exhibit 18 treats each college separately as well as the sample as a whole. It is at least interesting, if not predictive, to note that overall 11.0% of the sample leave after just one quarter of registration. Arts & Science, Business Administration and Engineering Colleges each are close to that norm. The Education College is quite a bit under the 11.0%. mm-Tech College is slightly higher. The number of students involved in the Pharmacy College data is too small to draw any conclusions, even tentative ones.

There are many more analytic elements to the table in Exhibit 18. One more will suffice to illustrate the possibilities in this simple technique. It is evident that students tend to stay registered for some multiple of three quarters, (three, six or nine quarters). From the standpoint of looking at retention, those who remain for nine or more quarters are more valuable in some societal sense than those who leave sooner. In this dimension the professional colleges of Pharmacy, Engineering, Education and Business Administration, in that order, do the best job of retaining students while the Arts & Science College almost exactly reflects the norm set by the entire sample.

EXHIBIT 18

Percent of Students Registering in Consecutive Qtrs. by College of Initial Registration

No. of Consecutive Qtrs. of Registration	Arts & Science	Bus. Adm.	Education	Engineering	Pharmacy	Comm Tech	Total
1	10.1%	10.9%	5.8%	12.0%	20.0%	15.2%	11.0%
2	4.0	0	2.9	2.4	0	7.5	4.2
3	13.4	10.9	13.6	11.9	20.0	11.6	12.6
4	2.7	1.8	4.9	0	0	4.1	3.2
5	.7	12.7	6.8	2.4	0	6.8	5.2
6	15.4	7.3	7.8	0	0	6.2	8.8
7	2.7	1.8	.9	7.1	0	8.2	4.2
8	2.7	7.3	1.9	0	0	6.8	4.0
9	25.5	29.1	33.0	47.6	60.0	10.3	25.2
10	6.7	7.3	11.7	9.5	0	2.7	6.8
Non-consecutive	16.1	10.9	10.7	7.1	0	20.6	14.8
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The most productive use of Exhibit 19 is probably to be found in the differential it makes plain as to non-consecutive enrollment. It is at least tenable in the light of this data to suggest that a highly structured program such as found in Pharmacy, Engineering, Education and Business Administration Colleges does not lend itself to easy in-and-out behavior, while the Arts & Science and Comm-Tech Colleges have more of a cafeteria choice which may make in-and-out behavior not only more possible but more palatable.

EXHIBIT 19

Selected Cumulative Percents of Students Registering
In Consecutive Quarters by College of Initial Registration

No. of Consecutive Qtrs. of Registration	Arts & Science	Bus. Adm.	Education	Engineering	Pharmacy	Comm Tech	Total
3 or fewer	27.5%	21.8%	22.3%	26.3%	40.0%	34.3%	27.8%
6 or fewer	46.3	43.6	41.8	28.7	40.0	51.4	45.0
10 or fewer	83.9	89.1	89.3	92.9	100.0	79.4	85.2
Non-consecutive	16.1	10.9	10.7	7.1	0	20.6	14.8

At least one way to view Exhibit 20 is to compare the total percent listed for each College column with the individual percent values entered in a given column. Thus Business Administration has 11.0% of the sample (10.7% of actual freshmen enrollment) but has less than 11.0% of the dropouts after quarters numbered 1, 2, 3, 4, 6, and 7; and less than 11.0% of the non-consecutive registrants. But Business Administration has 26.9% of those who leave after five quarters and the question naturally follows, Why this bulge, then? The Engineering College has 8.4% of the sample (8.1% of actual freshmen enrollment) but has less than 8.4% of the dropouts after quarters numbered 2, 3, 4, 5, 6 and 8 and less than 8.4% of non-consecutive registrants. But Engineering has 14.3% who drop out after seven quarters and the same question as before needs answering.

EXHIBIT 20

Percent of Students Registering for a Given Number
Of Consecutive Qtrs. by College of Initial Registration

No. of Consecutive Qtrs. of Registration	Arts & Science	Bus. Adm.	Education	Engineering	Pharmacy	Comm Tech	Total
1	27.3%	10.9%	10.9%	9.1%	1.8%	40.0%	100.0%
2	28.6	0	14.3	4.7	0	52.4	100.0
3	31.8	9.5	22.2	7.9	1.6	27.0	100.0
4	25.0	6.2	31.3	0	0	37.5	100.0
5	3.8	26.9	26.9	3.8	0	38.6	100.0
6	52.2	9.1	18.2	0	0	20.5	100.0
7	19.0	4.8	4.8	14.3	0	57.1	100.0
8	20.0	20.0	10.0	0	0	50.0	100.0
9	30.2	12.7	26.9	15.9	2.4	11.9	100.0
10	29.4	11.8	35.2	11.8	0	11.8	100.0
Non-consecutive	32.4	8.1	14.9	4.1	0	40.5	100.0
Total	29.8	11.0	20.6	8.4	1.0	29.2	100.0

The outcome of the kind of attrition and retention analysis that this sample data makes possible is a matrix of coefficients from which it is possible to predict the distribution of other sets of matrix data. This approach builds on the early work of Leontif of Harvard and his work in input-output analysis. The adaptations of this in enrollment data terms have been used with some success in making academic planning decisions.[5] One of the most effective efforts at finding a technique that will overcome the limitations of the ICLM seems to have been attempted at Pennsylvania State University by R. D. Newton and E. E. Enscore. They reasoned that coefficients, not unlike those in Exhibit 21 based on the current sample, may need modification. They have reported on their use of four modifying techniques, moving averages, exponential smoothing, exponential smoothing with trends, and least squares fit.[6] Still other efforts have encompassed measures of transition probabilities and updates of the transition probabilities through time.[7]

No single effort has as yet completely solved the basic forecasting problem inherent to the data involved. What is present seems to be the same kind of market forecast problem faced by corporations vending any product or service, with the added difficulty that since higher education is a personal service vended by an institution, the predictability of product characteristics and consumer response to them is not as readily attainable. The work of such researchers as Burnham[8] into the reasons for student response to course offerings seems to be an important breakthrough. Some of the work that seems most promising is that of Smith & Wagner,[9] George B. Weathersby,[10] Sanderson,[11] and Oliver and Hopkins.[12] It is undoubtedly appropriate to recognize that the earliest analysis of the ICLM and its deficiencies came from the work of Jewett[13] and his associates at Humboldt State in the California system.

EXHIBIT 21

Student Registration Matrix
Coefficients Based on Sample

No. of Consecutive Qtrs. of Registration	Arts & Science	Bus. Adm.	Education	Engineering	Pharmacy	Comm Tech	Total
1	.030	.012	.012	.010	.002	.044	.110
2	.012	.000	.006	.002	.000	.022	.042
3	.040	.012	.028	.010	.002	.034	.126
4	.008	.002	.010	.000	.000	.012	.032
5	.002	.014	.014	.002	.000	.002	.052
6	.046	.008	.016	.000	.000	.018	.088
7	.008	.002	.002	.006	.000	.024	.042
8	.008	.008	.004	.000	.000	.020	.040
9	.076	.032	.068	.040	.006	.030	.252
10	.020	.008	.024	.008	.000	.008	.068
Non-consecutive	.048	.012	.022	.006	.000	.060	.148
Total	.298	.110	.206	.084	.010	.292	1.000

The coefficients in Exhibit 21 have been applied to University of Toledo data with the following outcome:

EXHIBIT 22

Application of Matrix Coefficients
Given a class of 2,992 incoming freshmen

Beginning of quarter	There will be left
2	2,663
3	2,537
4	2,160
5	2,064
6	1,909
7	1,646
8	1,520
9	1,400

It should be realized that each of the figures above can be affected by the 14.8% that represents in-and-out (non-consecutive) registrants. The probable maximum is 443 students and the likely impact is 220 students. This is true because the in-and-out group is treated here as a random variable. The present data in the sample does not appear to warrant further analysis although further analytic treatments are planned for the entire population when such becomes available in compatible form for further computer manipulation.

Even before the sample data utilized above in matrix coefficient form became available, a regression study had been undertaken using three years of data. The outcome of these equations is given in the exhibit that follows.

EXHIBIT 23

Application of Regression Coefficients
Given a class of 2,992 incoming freshmen

Year	There will be on hand
Sophomore	2,844
Junior	1,768
Senior	1,390

The numbers projected above are not intended to be directly comparable to the figures in Exhibit 22. The data above reflects the number expected to be on hand with a given number of credit hours that qualify the student to be ranked as a sophomore, junior or senior. The data in Exhibit 22 refers solely to the consecutive character of registration and not to the number of credit hours taken. Inspection of the data indicates that some of the students with records of nine or ten consecutive quarters of registration have registered for as little as a single course in each quarter, thus after ten quarters of registration their credit hour totals might still fall short of ranking as a sophomore.

This distinction, cited above, may be of considerable significance in analytic interpretation of enrollment data. Too often in the past attention has been paid solely to the achievement of certain credit hour totals. It may well be of greater significance to know the consistency with which a student participates in the higher education experience. This would be in parallel with the findings in marketing as to the importance of brand loyalty and patronage loyalty in the market position of a product or the share of the local market of a retailer.

Longitudinal Research Possibilities

The more the data on enrollment is studied the more it becomes evident that the data reflect decisions in a time setting. The decisions represented by a course registration sum up a variety of personal experiences and peer group forces operating in little understood ways upon each student to effect the datum we see in enrollment matrices. But it appears certain that the student experiences and peer group influences do not operate in an instant of time. They appear more likely to be cumulative and thus it begins to appear that the issue for analysis is not that of macro-analysis versus micro-analysis but rather that the research imperative is for longitudinal study as opposed to cross-sectional analysis. By its very nature, longitudinal study requires a micro-analytic type of approach. The situation seems much like that which has faced marketers for some time and in which market research has made some contributions.

Before becoming too enamoured with the idea of longitudinal research it seemed prudent to examine what could be learned in the present instance from the data on the entering freshmen of Fall, 1969. In one of several computer runs, data was printed on the college and major as of each quarter and the courses registered and taken in that quarter and subsequent quarters. The second author of this paper serves on the faculty of a Department of Operations Analysis. It was of particular interest, thus, to examine the thirteen majors in Operations Analysis. Of these thirteen students, none declared an Operations Analysis major as an entering freshman. Four of the thirteen came from the "Business-Undecided" category, four more came from specific Engineering college categories, two each came from freshmen who entered specifying Arts & Science and Comm-Tech, while the remaining one originally chose to matriculate in Education. There does not seem to be any pattern as to the time when selection of a major (or a new major) is made by these students. Two of the thirteen, as a matter of fact, are the in-and-out variety of student. The first of these began as a "Business-Undecided" student, took one quarter, then stayed out two quarters, came back for another, stayed out one more quarter, came back for this third quarter of registration, then left and has remained out of school for the remaining four quarters in the current analysis. The other non-consecutive registrant originally chose Engineering as a major, attended three quarters, then dropped out for four quarters, then returned and has been registered in each of the last three quarters in the current analysis. In each of these cases there is no apparent grade difficulty. Each of them made a change of major after returning from being out of school. The quarters when a change of major was registered vary all over the time span available in this analysis. The remaining three Business students declared themselves in the 5th, 6th and 7th quarters, while the remaining three Engineering students changed to the College of Business Administration and an Operations Analysis major in the 3rd, 9th and 10th quarters. Neither of the junior college (Comm-Tech) students waited until they had completed six quarters there, but made their choice in the 4th and 5th quarters. The two Arts & Science students made their change of major and college in the 7th and 8th quarters while the single Education student made a switch in the 9th quarter. Thus, even with something so fundamental as the decision about a college and major we find:

Quarter in which declared change in major	No. of Students
2	1
3	1
4	1
5	3
6	1
7	2
8	1
9	2
10	1

It would obviously be interesting to learn something of the reasons for change. Both the change to and the change away from factors need research.

But what we have learned in looking at present data suggests that lack of pattern is not limited to any single dimension of the registration process. It is a pervasive phenomena the limits of which have yet to be found in the current study. For example, the students referred to above were studied in detail as to each registration they made. A similar analysis had been undertaken by the second author in an earlier study.[14] At that time, it represented a retrospective cohort analysis type of undertaking. In the present study it was possible to view the data in a sequential fashion rather than look back at it, considerably after the fact. But whether viewed from the advantage of hindsight or with the immediacy of the sequential happening, the lack of pattern is the predominant impression. Exhibit 24 sets forth the sequential registration for selected required courses in the College of Business Administration. The sample is composed of the thirteen students who became majors in Operations Analysis before the summer session quarter of 1972. In general courses numbered 200 or below should be taken before the 7th quarter, which for these entering freshmen of the Fall of 1969 would have been, thus, before the Fall of

EXHIBIT 24

Business Administration
Sequential Registration Sample

		F 69	W 70	S 70	F 70	W 71	S 71	SS 71	F 71	W 72	S 72
212	150	1	3	3	2	1	1	-	1		1
	190		1	2	1	3	2	1	1		1
	300			1					2	1	1
	302										
224	211				2	2	2	1	3	1	
	221						4	2	2	1	
	316								1	4	3
	322										3
	357										1
	417									1	
	419									2	
236	312									2	4
	313									1	
248	303								1	2	1
	304								1	2	6
260	327								4		2
284	119	3	1	3	1	3	1		1		
	217			2		1	5		2		
	218						3	1	3	3	
	220		1	1			1		1	3	2
	320								2	3	2
	331				1						
	332										1
	333										2

1971. There are at least 18 instances where these lower division courses have not yet been registered for and taken (as of Spring, 1972). In general, no 300 level or above numbered course would be taken before the 7th quarter of registration. There seem to be only two instances where any of these thirteen students registered for an upper division course ahead of their standing.

Exhibits 25 and 26 should be considered together. Exhibit 25 represents a sample taken from College of Business Administration graduates of June 1971.[15] The lines connect the registration choices for the group through time. The larger sample group involved in Exhibit 26 did not lend itself to the graphic line-drawing of Exhibit 25. The reader of this paper may want to connect some of these course registrations through time for himself. Try connecting each and every like number. For example, 150 is Accounting 150, the beginning accounting course. It should be part of every student's first or second quarter of study in business administration. Other early course registration recommendations are 190 which can only follow 150 as the second course in beginning accounting, or 119 or the 217-218 pair or 211 and 221. No matter what method you adopt in creating the lines connecting these registrations you end up with a zig-zag bewildering pattern of lines crossing other lines that demonstrates the very lack of pattern that has been the argument of this paper.

Conclusion

The present study began in an expectation that some of the already developed analytic tools when properly tuned could be applied to the data. The induced course load matrix fails as has been demonstrated. The possibilities for developing a probability transition matrix and finding a Markhov type of solution seem less promising now than when the study began. It seems likely that

EXHIBIT 25

EXAMPLE OF SEQUENCE ANALYSIS

PERIODS OF REGISTRATION (NOT NECESSARILY CALENDAR CONSECUTIVE BUT CONSECUTIVE AS TO REGISTRATION)

Student #	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
1	327	217) 316)	320) 303)	218) 221)	211) 322)	304	417	419	313	312		
2	190) 211) 221) 312)	320) 322)	316) 327)	304	303	419	417					
3		211	150	221	316	322	320) 327)	417	218) 312)	190) 419)	304) 300) 420)	
			190	211) 300)	221	327) 322)	316	304) 312) 303)	320) 417)	218	419	
2, 3, 4, & 6	217	#4) 5) 6) 150										
5			211) 221)	218	119) 300) 303)	327	316) 322)	312) 320)	417	419		
6			190) 211)	218) 221)	119) 320) 303)	304) 312) 316)	419)	327) 322)	417			
Recommended Sequence	150	190) 217)	218) 300)	211) 221)	303) 312) 313)	320) 327) 322)	316) 304)	417	419			

EXHIBIT 26

Sequential Cohort Analysis
Registration Period

Student No.	1	2	3	4	5	6	7	8	9	10
1	150	190 119	300 217		211	221 218		316 327 304 320	417 419	312
2		150	190 119	211	217	218 221		320 300 327	316 312 419 303	304
3					150	190 217	221	119 218	211	316
4	119		150		190	217	218 190			
5		150		150	119	190 217	211	221 218	300 320 304	316 327 303
6	119									
7			119		211			150 217 211		
8			150	211 119	190	221			218	316 327 304 320
9			150	190	119	211 217		300 218 221	316 320	322 304 312
10						119 150		211 217 190	221 218	190 304 312 320
11	119	150	190 217			211 218	221	303 327	316 313 312 320	322
12				150	119 190	221 217		211	218	300 304
13			119					327	316 304 303	322 312

while transition probabilities can be determined for each course for each quarter, that the achievement of a steady state is not a near term likelihood. The idea of using exponential smoothing has considerable appeal. Here again, as in the Markhov process, is the possibility for accommodating varying values for the coefficient through time. But the achievement of any kind of optimal stability in a value for α seems not too likely.

What appears to the present authors as a possible conclusion is that much more needs to be known than is presently known. For example the present data awaits further analysis aimed at answering such questions as: Who enrolls for what and when? Who is not enrolled at all, who is not enrolled as a college major, who is not enrolled in the next course in a sequence of courses or requirements and where are they instead of where they were expected to be registered. How big is the problem of non-consecutive enrollment? How big is the "leave and never return" problem. And ultimately, after the descriptive analytics have been defined for the entering freshmen of Fall 1969, and for later groups of entering freshmen, it will be imperative to get at something as to Why. The final element that seems evident now is a study of how answers such as those to be sought above can be found in the most timely and efficient manner possible. The only conclusion this paper can claim is the conclusion that answers such as those sought above cannot be found in the familiar aggregate numbers game. It seems more likely that one or more management science tools will play a part in the answers to be sought.

FOOTNOTES

[1] see for example Robert C. Judd, "Micro-Analysis in Higher Education Decision Making," paper delivered at ORSA 40th National Conference, October 1971, or "Mico-Analytic Methods in Economic Research of Higher Education," 1971 Proceedings of Business & Economic Statistics Section, American Statistical Assn., Washington, D.C. American Statistical Assn., 1972, pp. 399-404.

[2] Warren W. Gulko, The Resource Requirements Prediction Model, An Overview, Boulder, Colorado, NCHEMS at WICHE, 1971, 36pp.

[3] Robert Huff, et.al., Implementation of NCHEMS Planning and Management Tools at California State University, Fullerton, Boulder, Colorado, NCHEMS at WICHE, 1972, 9? pp.

[4] R. D. Newton & E. E. Enscore, A Model for Prediction of Instructional Activity in an Institution of Higher Education, University Park, Pa., Pennsylvania State University, 1971, 35 pp, originally a paper presented at the 18th International meeting of TIMS at Washington, D.C., March 1971.

[5] see the work of Richard F. Barton, Data and Information Requirements for College and University Planning, Lubbock, Texas, Texas Technological University, 1971, 21 pp., or see the work of Paul Hamelman, Virginia Polytechnic Institute, Blacksburg, Va. or consult the originator's basic work, W. W. Leontief, The Structure of the American Economy-1919 to 1939, New York, Oxford University Press, 1951.

[6] see Newton & Enscore, op.cit., pp. 16-24.

[7] see for example Huff, op.cit., pp. 40-55.

[8] John M. Burnham & Earl D. Thorp, "Toward Reliable Revenue Forecasting," mimeo School of Business Administration, University of Miami, Coral Gables, Fla.

[9] Donovan E. Smith & W. Gary Wagner, Space: Space Planning and Cost Estimating Model for Higher Education, Berkeley, Calif., Ford Foundation Program for Research in University Administration, 1972, 77 pp. (Paper P-34).

[10] see for example George B. Weathersby & Milton C. Weinstein, A Structural Comparison of Analytical Models for University Planning, Berkeley, Calif., Office of the Vice President-Planning and Analysis, University of California, 1970, pp. 15-6; or Frederick E. Balderston & George B. Weathersby, PPBS in Higher Education Planning and Management: From PPBS to Policy Analysis, Berkeley, Calif., Ford Foundation Program for Research in University Administration, 1972, pp. 62-3 and 65 are especially good overview.

[11] Robert D. Sanderson, The Expansion of University Facilities to Accommodate Increasing Enrollments, Berkeley, Calif., Office of the Vice President-Planning and Analysis, University of California, 1969, 46 pp. (Paper P-3).

12. Robert M. Oliver and David S. P. Hopkins, "An Equilibrium Flow Model of a University Campus," Operations Research, Vol. 20, No. 2, (March-April 1972) pp. 249-64.

13 Frank I. Jewett, et.al., The Feasibility of Analytic Models for Academic Planning, Los Angeles, Cali rnia State Colleges, 1970, 130 pp.

14 Judd, op.cit., ORSA per pp. 8-18.

15 Judd, op.cit., P eedings, pp. 400-2.